PATENT SPECIFICATION

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PROVISIONAL SPECIFICATION

Improvements in or relating to the Duplication of Diffraction Gratings

I, THOMAS RALPH MERTON, M.A., D.Sc., F.R.S., a British Subject, of Winforton House, Hereford, do hereby declare the nature of this invention to be as follows:—

This invention comprises improvements in or relating to the duplication of diffraction gratings.

Closely ruled diffraction gratings are very expensive and it is already known to prepare economical duplications of such gratings in collodion by casting a collodion solution as a thin film upon the surface of a master diffraction grating, then allowing the skin to dry by evaporation of the solvent vehicle and subsequently detaching the skin from the master grating. Such a detached skin carries a mirror-image of the rulings of the master grating and may be mounted for use on a glass plate or prism, so producing a diffraction grating which is economical to prepare but which is sufficiently good for non-critical work.

The production of collodion grating-images according to this method is a somewhat lengthy and tedious procedure and requires considerable manipulative skill. Evaporation of the solvent vehicle of the collodion solution cannot be hurried otherwise the film becomes reticulated and irregular in thickness.

It is an object of the present invention to provide means whereby gratings may be duplicated rapidly and, if desired, over areas which are large compared with the ruled area of the master grating. It is a further object of the invention to provide means for utilising such duplicate gratings in the manufacture of foils capable of yielding diffraction effects.

The present invention accordingly provides a method of duplicating diffraction or like gratings which consists in first preparing a primary mirror-image duplicate of the grating surface and thereafter preparing therefrom a primary replica of the master grating by employing the primary duplicate as a matrix in reproducing its rulings in a medium which will conform to the rulings and which is sufficiently resistant or which can be rendered sufficiently resistant as to permit of the preparation of further duplicates therefrom.

According to a further feature of the invention two or more secondary mirror-image duplicate gratings are to be prepared from the primary replica and such secondary duplicates then employed in the preparation of a secondary replica of the master grating which exhibits a ruled area more extensive than that of the master grating.

According to a further feature of the invention two or more primary replicas of the master grating are so assembled as to permit of the production therefrom of a secondary duplicate which exhibits a ruled area more extensive than that of the master grating.

Further, the invention includes the assembly of two or more secondary replicas of the master grating prepared as hereinbefore set forth so as to permit of the production therefrom of a tertiary duplicate which exhibits a ruled area more extensive than that of a single secondary replica and which may be employed in the preparation of a tertiary replica of the master grating.

A replica of the master grating may be prepared by squeegeeing the grating surface of a mirror-image duplicate into intimate contact with a swollen protein medium which is capable of hardening under the action of a fixative or hardening agent, allowing the medium to dry in contact with the duplicate and thereafter detaching the duplicate. Gelatine impregnated with a dichromate serves well for this purpose and after detachment of the duplicate can be hardened throughout by exposure to light. Alternatively the replica may be prepared from a solution of a material such as dichromated photo-engraving glue which can be converted into an insoluble enamel under the action of heat. Again, a replica may be formed by depositing, by cathodic atomisation, a film of metal on to the grating surface of a mirror-image duplicate, thereafter backing the deposited film with a suitable material

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and stripping the combination of metal and backing.

The invention also includes a method of producing diffraction and like gratings on materials which can be cast or moulded, which consists in first preparing a replica (for example a primary replica or an assembled group of primary replicas or a secondary replica or a tertiary replica) in the manner hereinbefore set forth and then employing the replica as a die or mould in impressing the grating upon the material.

Thus, diffractive foils of large surface area may be prepared from varnishes, such as a solution of cellulose acetate or collodion by coating the grating surface of a built-up replica of large surface area with the varnish made up in a solvent vehicle which is a non-solvent for the material of the replica, then allowing the varnish to dry and thereafter detaching the varnish film. A varnish of pyroxylin in amyl acetate may well be used in conjunction with a dichromated gelatine replica.

Diffractive foils of large surface area may also be manufactured from alginate films, uncoated "Cellophane" and like foils which swell when wetted, by placing the foil in a swollen condition in intimate contact with the grating surface of a built-up replica of large surface area and then allowing the foil to dry out in contact therewith. The replica grating may be supported upon a platen or may surround a roller or be disposed upon an endless band, and any of the supports may be provided with suitable heating means to expedite drying of the foil. By providing suitable feeding and stripping means for the foil it is possible to prepare diffractive foil in a continuous manner at very low cost.

In a specific method of carrying out the invention, which will now be described by way of example, the procedure is as follows:—

In the manufacture of flexible foil materials of large area carrying diffraction gratings according to the invention, it is first necessary to multiply and duplicate a diffraction grating from a master grating over a large area to expedite reproduction of the grating surface upon the flexible foil. To this end a solution of photographic pyroxylin is dissolved in amyl acetate in the proportion of five parts by weight of pyroxylin to one hundred parts of solvent, and the solution so formed poured on to the grating surface of the master grating. The master grating may conveniently comprise a grating having 20000 lines per lineal inch ruled in speculum metal. The grating is tilted to cause the solution to float evenly over the ruled surface and then put aside to dry for 24 hours at room temperature. The quantity of solution poured upon the grating surface should be very carefully regulated, because an excess of solution yields a poor result, the surface of the skin becoming reticulated; if too little solution is used the resultant skin is too thin to be properly handled. After drying the skin, the grating and adherent skin is placed in a photographic dish containing water at about 40° C. After an immersion period of approximately 5 to 15 minutes, the collodion skin becomes detached from the grating and the master grating may now be lifted vertically from the dish with the loosened skin upon it and then lowered into the dish with the grating on the slant. The skin then becomes detached and floats upon the surface of the water. The collodion skin carries a mirror-image duplicate of the rulings upon the master grating, and this primary mirror-image duplicate is then to be used in making a primary replica of the master grating in the following manner.

An unused photographic plate is fixed in hypo, and after thorough washing is soaked in water at approximately 25° C. for 10 minutes. The plate is then soaked in a 1% solution of potassium or ammonium dichromate for 10 minutes, so as thoroughly to impregnate the gelatine with dichromate solution. The collodion skin is then floated with its rulings in contact with the surface of the dichromate solution, and the photographic plate is lifted out of the solution with the gelatine layer in contact with the skin. The position of the skin relatively to the gelatine is adjusted, and a sheet of absorbent material, such as filter paper, is placed over the skin, which is then squeegeed to the gelatine film. The squeegeeing is effected in a very thorough manner so as to drive any small particles between the contacting layers into the gelatine. After squeegeeing, the photographic plate is put aside to dry which, after the first hour, may be carried out at 30° C. Drying is continued for 24 hours. The whole of the operations when the dichromate is present up to this stage are carried out in the dark. When thoroughly dry, the collodion grating is pulled off the gelatine plate, care being taken not to break the skin or, if the skin is broken, to remove the broken pieces of skin from the surface of the gelatine. The gelatine now displays a brilliant replica of the original master grating, and is then exposed to a strong light for approximately one hour to harden the

gelatine by reduction of the dichromate. The gelatine replica so formed comprises a primary replica of the master grating in a material which is sufficiently hard to permit of the preparation of further collodion mirror-image skins therefrom.

To prepare such further mirror-image skins, a small quantity of collodion solution is poured upon the grating surface of the gelatine replica as before, but two small pieces of cotton or silk are laid at the ends of the gelatine outside the ruled surface so that the solution overlaps the threads when spread over the plate. These threads facilitate subsequent stripping of the collodion film from the gelatine grating. After allowing the collodion to dry for approximately 24 hours, the detachment of the collodion film is effected by starting to strip by lifting a thread, and then running a spatula around the edge of the collodion film so as to free it. The skin can now be pulled off the gelatine replica without damaging the replica in any way. Preferably the skin should be detached by drawing the skin across the surface of the replica and not by pulling it away from the surface. It should be noted that the detachment of the secondary duplicate mirror-image skin so formed takes place in the dry stage, and this skin can now be used for making further gelatine replicas. According to the next step of the process a number of secondary mirror-image duplicate skins are prepared from the primary gelatine replica and are used to prepare a secondary gelatine replica having a ruled area which is considerably in excess of the master grating. The secondary duplicate skins are, according to a first method, trimmed with a sharp instrument such as a razor, so that there is a margin of collodion outside the ruled surface of approximately 2 mm. in width, and the trimmed skins are squeegeed in juxtaposition upon a swollen dichromate gelatine film. The film is dried and later exposed to light, as set forth hereinabove, and the skins removed to give a secondary gelatine replica having a ruled area which is considerably larger than that of the master grating. Alternatively, a plurality of secondary mirror-image duplicate skins may be mounted upon a plain glass plate and affixed thereto with the ruled surfaces in contact with a glue comprising equal parts by weight of liquid photo-engraving glue (from Hunters Penrose) water and 5% ammonium dichromate solution. This operation calls for considerable manipulative skill and it is preferable at this stage to mount the plurality of skins in one line with overlapped joints on a dichromated gelatine plate according to the first method, with a small quantity of the aforesaid glue in the overlap between the skins.

The next step of the process is to prepare a number of tertiary mirror-image duplicate skins from the long gelatine matrix and to mount this with overlapped joints upon a fresh dichromate gelatine film for the preparation of a tertiary replica in gelatine. This procedure should be repeated until a replica in gelatine of the master grating is obtained of the desired size for use as a die or mould in the preparation of foils, for example in "Cellophane" or alginates of a desired surface area, as described hereinafter.

In the preparation of such foil material carrying diffraction rulings, collodion skins are prepared from gelatine replicas of large surface area and are mounted in juxtaposition, or otherwise, on a copper or brass cylinder, using a glue composition as herein set forth between the ruled surface of the skins and the cylinder. The skins are squeegeed until the glue layer is quite thin and the surface of the cylinder is very finely finished to ensure an even distribution of the glue. After squeegeeing the glue is allowed to dry by evaporation of the liquid content through the free outer surface of the skins, which are then pulled away leaving the cylinder covered with gratings in dichromate glue. The cylinder is then heated to approximately 250° C. for, say, 5 minutes, and this treatment converts the dichromate glue into a very hard enamel carrying a more or less permanent repeat pattern of the rulings of the master grating in replica. The cylinder should then be cooled and is then ready for use in the preparation of diffractive foils.

There are two main methods of producing diffractive foils from the replica cylinder. Thus, in the first place, the foil material may be cast upon the cylinder in solution, allowed to dry thereon and then stripped. The second method takes advantage of the property of certain materials to swell when damped with water, and to retain deformations impressed in the swollen state when dried. According to this latter method, uncoated "Cellophane" or alginic acid foil is wetted and squeegeed into contact with the cylinder, or even merely placed upon the cylinder with an interposed layer of water. If the cylinder is then suitably heated from the inside, the water dries out through the foil, and when the whole of the water has evaporated, the foil is found to separate easily from the

cylinder with a perfect imprint of the grating surface upon it.

The production of diffractive foils according to the casting method or according to the swelling and drying method may be arranged to proceed in a continuous manner. Thus a solution of cellulose acetate may, for example, be cast on to a rotary replica cylinder at one station, and a dry cellulose acetate film stripped from the cylinder at another station. Again, a swollen film of "Cellophane" may be fed in contact with a rotary replica cylinder and later removed therefrom when dry. The cylinder may be replaced by a travelling band bearing an endless succession of replicas, for example a copper band provided with a surface layer of dichromate gelatine replicas.

According to a further simple and rapid method for finally impressing the grating in cellulose acetate foil the foil is passed over a rotating drum carrying the matrix, the bottom of the drum dipping in a trough containing acetone or other suitable solvent. When the drum is rotated at the appropriate speed the amount of solvent carried round is such that the surface of the foil is momentarily softened so that it takes up the grating impressions. By the time the foil is wound off the drum at the other end the small amount of solvent has diffused into the body of the foil, which feels perfectly dry and hard. By a suitable selection of solvent and drum size it is possible to dispense with means for heating the drum according to this method.

A variety of materials may be provided with diffraction rulings according to the invention. Thus, any cellulosic material or cellulose ester or ether may be employed. The materials may be cast or moulded in a swollen condition according to their respective properties of swelling or not. Further materials which may be used are chlorinated rubber, parchmentised paper and mixtures of paper with alginic acid and alginates. Substances which are capable of deformation under heat may also be impressed with diffraction rulings such, for example, as certain synthetic resins.

It should be understood that whilst it is preferred to use a final impression matrix of hard-burnt glue-enamel (more particularly in the case when the foil to be treated comprises "Cellophane" or alginic acid), it is possible when casting a cellulose acetate solution to employ unburnt hardened gelatine as the matrix material.

The diffractive foils prepared according to the invention are particularly useful for ornamental and decorative purposes. When using transparent or translucent foils, it is possible to enhance the effect by depositing a metallic film, for example, a gold or silver film, upon the unruled surface of the film by cathodic atomisation or other sputtering process.

Dated this 10th day of January, 1936.

BOULT, WADE & TENNANT,
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COMPLETE SPECIFICATION

Improvements in or relating to the Duplication of Diffraction Gratings

I, THOMAS RALPH MERTON, M.A., D.Sc., F.R.S., a British Subject, of Winforton House, Hereford, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention comprises improvements in or relating to the duplication of diffraction gratings.

Closely ruled diffraction gratings are very expensive and it is already known to prepare economical duplications of such gratings in collodion by casting a collodion solution as a thin film upon the surface of a master diffraction grating, then allowing the skin to dry by evaporation of the solvent vehicle and subsequently detaching the skin from the master grating. Such a detached skin carries a mirror-image of the rulings of the master grating and may be mounted for use on a glass plate or prism, so producing a diffraction grating which is economical to prepare but which is sufficiently good for non-critical work.

The production of collodion grating-images according to this method is a somewhat lengthy and tedious procedure and requires considerable manipulative skill. Evaporation of the solvent vehicle of the collodion solution cannot be hurried otherwise the film becomes reticulated and irregular in thickness.

It is an object of the present invention to provide means whereby gratings may be duplicated rapidly and, if desired,

over areas which are large compared with the ruled area of the master grating. It is a further object of the invention to provide means for utilising such duplicate gratings in the manufacture of foils capable of yielding diffraction effects or of surfaces on other substances yielding diffraction effects for the purpose of decoration.

The present invention comprises a method of reproducing from an original diffraction surface a copy thereof which consists in applying directly to the surface of the original a material capable of taking an impression or cast therefrom, thus forming one or more primary negative replicas, stripping therefrom the primary negative replica or replicas, then making one or more positive replicas of the original grating by applying directly to the said primary negative replica or replicas a second material which does not dissolve or mix with the said negative replica or replicas and is capable of taking an impression or cast therefrom, thereafter separating the second material and primary negative replica from each other, and then in like manner making further replicas from the said positive replica or replicas.

The invention further comprises a method of reproducing from an original diffraction surface a copy thereof of area larger than the original, which consists in taking directly from the original in a material capable of taking an impression or cast therefrom a plurality of casts to form negative replicas, and using these juxtaposed as dies in the formation of a larger positive replica of the diffraction surface in a second material which in the direct casting operation does not dissolve or mix with the first.

The material for making any of the said replicas may be a swollen gelatinous material which has the impression produced thereon by being allowed to dry in direct contact with the surface from which the impression is taken. The gelatinous material may be glue containing a hardening agent and may be subjected to treatment for the purpose of hardening it after the surface from which the impression has been taken has been stripped off.

The replicas may be made of cellulosic material. It will be observed that the gelatinous materials and cellulosic materials belong to classes of organic substances of which the one class is softened by aqueous agents which have no solvent effect upon the materials of the other class, which are softened by reagents such as acetone. Instead of employing as originals and replicas gelatinous materials and cellulosic materials it is possible for a replica to be made from a cellulosic material and a replica thereof from another cellulosic material of a kind softened by an order of reagent which has no solvent effect on the first mentioned replica.

The invention further comprises a method of preparing a diffraction surface of a desired area larger than an original diffraction surface which consists in forming from the said original a cast thereof by applying directly thereto a material which is thereafter stripped therefrom, then forming therefrom a plurality of casts by bringing it in contact with a material which is capable of being separated therefrom after casting, then using these casts juxtaposed as dies to form in like manner an enlarged die-surface from which in turn a series of further casts is taken by applying directly a material which in every case is capable of being stripped from the dies after casting if and so far as may be necessary to build up a still further enlarged diffraction surface of the desired area and using the said diffraction surface having the desired area as a matrix for the production of casts in a material which is capable of being stripped from the said matrix. In this connection it will be understood that the term "original grating" means any diffraction surface used as a starting point and that the term "casting" includes any method of moulding one surface from another either by pouring liquid material thereon or pressing a previously formed but soft surface thereon or otherwise.

The material of which the said matrix is composed may consist of a glue (for instance a photo-engraving glue) containing a hardening agent and may be subjected to heat for the purpose of hardening it.

The enlarged diffraction surface produced by the method as hereinbefore indicated may be employed as a die or matrix to form a diffraction surface upon a thin continuous film or sheet of a cellulosic, alginic or like material such, for example, as the thin transparent cellulosic material sold under the registered Trade Mark "Cellophane".

It is an important feature of the present invention that such material may be pre-formed, treated with a solvent or softening agent sufficient to bring it to a soft state and then dried while in contact with the die or matrix. Preferably the diffraction surface is formed on a roller and the film or sheet material is treated with a solvent by applying the solvent to the roller and pressing the film

or sheet material thereon. By "preformed" is meant formed prior to its contact with the die or matrix, in contradistinction to being poured on to the die and spread thereon in liquid form.

One specific method of carrying out the invention will now be described by way of example with reference to the accompanying drawings which illustrate in the successive figures the steps in the process:—

Figure 1 is a diagrammatic section of a master grating with a collodion skin thereon;

Figure 2 is a diagram illustrating the removal of the collodion skin from a grating.

Figure 3 illustrates the method of applying the said collodion skin to and stripping it from a gelatine surface;

Figure 4 illustrates the casting of further collodion skins from the gelatine surface;

Figure 5 illustrates the manufacture of an enlarged grating in gelatine;

Figure 6 the cast of large collodion skins therefrom;

Figure 7 the manufacture of a gelatine impression therefrom;

Figure 8 the preparation of an enlarged diffraction surface around a portion of a cylinder;

Figure 9 the completion of the same, and

Figure 10 is a diagram of the manufacture of continuous lengths of transparent foil upon a cylinder provided with a diffraction surface.

In the manufacture of flexible materials of large area carrying diffraction gratings according to the invention, it is first necessary to multiply and duplicate a diffraction grating from a master grating over a large area. The master grating may be any original desired, for example it may be ruled on speculum metal with, say, 20000 lines per lineal inch. As will be evident the degree of perfection of the master grating employed will determine the brilliance of the products. The first operation is to cast a skin of pyroxylin on the master grating in known manner. This is done by pouring a solution of pyroxylin, dissolved in amyl acetate in the proportion of 5 parts by weight of pyroxylin to 100 parts of solvent. This is then dried, which will take about 24 hours at room temperature.

In Figure 1, 11 represents the master grating and 12 the pyroxylin skin poured thereon. The thickness of the skin and the dimensions of the lines 13 ruled on the master grating are greatly exaggerated in Figure 1 in order to render them clearly visible.

The quantity of solution employed needs to be carefully regulated so as to obtain a skin of the desired thickness. Too little will yield a skin which is too thin to be properly handled and too much will lead to poor drying, the surface of the back of the skin becoming reticulated.

After drying, the grating and adherent skin are placed in a photographic dish 14, Figure 2, containing water at about 40° C. After an immersion period of approximately 5 to 15 minutes, the collodion skin becomes detached from the grating and if the grating 11 is lifted from the dish with the loosened skin upon it and then lowered into the dish slantwise, as illustrated in Figure 2, the skin will float itself off, remaining on the surface of the water. The skin carries a mirror-image of the rulings on the master grating and this is to be used in making a primary replica of the master grating.

Referring to Figure 3, 15 represents a photographic plate having a gelatine surface 16. Preferably the silver emulsion is removed by fixing the plate in hypo and washing. Subsequently the plate is soaked with a hardening agent, for example a 1% solution of ammonium or potassium dichromate for ten minutes. On the wet plate the collodion skin 13 in the dish 14 is gently floated and on lifting the photographic plate out of the dish 14 the skin will remain upon it. The position of the skin relatively to the gelatine can then be adjusted, a sheet of blotting or filter paper passed over the skin and the whole squeegeed together. The skin and the plate are put aside to dry and when thoroughly dry the skin 13 is pulled off. This can easily be done by carefully lifting one edge with a spatula or knife and then pulling in the direction indicated by the arrow 17, Figure 3. The gelatine 16 now displays a brilliant replica of the original master grating. It can be hardened if desired by exposure to light if dichromate has been used. Alternatively it can have been soaked in formalin before moulding so that the formalin hardens it on drying. It can be regarded as a kind of master grating which, being less expensive than a ruled master grating such as the ruled grating 11, Figure 1, can be employed with more freedom in the production of further collodion skins. It is necessary for the production of a large diffraction surface according to this invention to prepare a considerable number of collodion skins. For this purpose the plate 15 with its hardened gelatine coating 16 is laid on a flat surface and collodion skins 18 are

poured upon it, dried and stripped one after another until a sufficient number have been collected. Before pouring the skins two small pieces of cotton or silk 19 are laid on the gelatine surface just outside the ruled area thereon so that the solution overlaps the threads when spread over the plate. Conveniently a small stick of wood 20, such as a matchstick, supports the cotton threads during the pouring operation to prevent the threads from hanging down and syphoning the collodion solution away while it is wet. These threads facilitate subsequent stripping of the collodion film from the gelatine grating. After allowing the collodion to dry for approximately twenty-four hours detachment is effected by starting to strip by lifting one or both of the threads 19, then running a spatula round the edge of the collodion film so as to free it and then stripping it off, pulling in the direction indicated by the arrow 17 in Figure 3. It should be noted that this detachment must be effected dry without the floating operation indicated in Figure 2.

When a sufficient number of collodion skins 18 have been made a large gelatine duplicate can be made on a glass plate 21 (Figure 5) which is covered with a gelatine film 22, containing a hardening agent similar to that on the film 16 in Figure 3. The skins 18 are first trimmed and are then laid on the surface 22 while the latter is wet, if desired, so that they overlap one another at their edges. The junctions are preferably painted with glue as indicated at 23. The skins can either be laid regularly so as to cover the whole of the surface with a uniform series of ruled lines or they can be laid with any desired pattern. After drying off the water as before the skins can be stripped. If lifting is started with the skin which was first laid and this is pulled off in the manner indicated by the arrow 24, Figure 5, the other skins will be lifted off with it one after another.

The plate 21 now carries an enlarged diffraction area and can be used as indicated in Figure 6 for pouring a correspondingly large collodion film 25 provided as before with cotton or silk threads 26* at the corners to facilitate stripping.

The operations above described can be repeated if desired, using a number of the larger skins such as 25 lapped together on a still larger glass plate so as to provide a further enlarged diffractive area.

When a diffractive area of the required size and pattern has been produced on a large enough collodion skin or skins by the methods above described the possibility comes into view of preparing a cylinder carrying a diffractive surface so that the surface may be reproduced by the cylinder on a continuous length of thin transparent foil. If the foil to be produced is a material such as cellulose acetate, which is ordinarily prepared by casting a thin film upon a rotating cylinder, the surface of the cylinder may be provided with a diffractive surface moulded in a gelatinous substance or photo-engraving glue applied direct to the cylinder and formed with diffractive lines by applying the collodion skins directly thereto. If, however, the foil which is to be rendered diffractive is made of regenerated cellulose, such as "Cellophane", the step of impressing the lines upon the "Cellophane" is conducted by bringing a water-resistant material such as pyroxylin into close contact with the cellulosic material while the latter is wet and the steps necessary for the latter process are those which have been illustrated in the drawings.

Referring to Figure 7, this shows a collodion skin 25 after it has been squeegeed into close contact with the gelatine surface 26 on a paper backing 27. Gelatined paper, similar to photographic paper, can be employed for this purpose. The paper and gelatine are soaked in water before being squeegeed together with the collodion 25. The latter operation can be conducted by passing the two sheets together through rubber-covered rollers like a mangle. After the material has dried it is split apart as indicated by the arrows 28 at the right hand side of Figure 7. This is, of course, a delicate operation which may require the co-operation of more than one operator.

The next operation is to mould a diffractive surface on a cylinder from the gelatine-coated paper 27. To this end a cylinder 30, Figure 8, having a smooth metallic surface, for example of brass, and of a suitable diameter, say 4 feet, is taken and covered with a layer of celluloid 29 by any appropriate process. A protective coating of glue 31 is applied over a portion of the surface of the cylinder, the edges 32, 33 of the glue being parallel with the axis of the cylinder. At a suitable spacing from the glue-covered strip there is a second strip 34 of glue, the distance between the edges of the strips 31, 34 being somewhat less than the width of the diffractive surface on the paper 27. The paper 27 is laid with one edge overlapping the glue 34 and with a squeegee roller 35 pressing on this edge as indicated in chain lines in Figure 8. Into the V-shaped gap between the paper 27 and the surface 29 of the roller 30 there is poured a small quantity of

pyroxylin solution 36 and this is pressed out over the surface of the roller 30 by advancing the squeegee roller 35 and gradually squeegeeing the gelatine paper down on the roller surface, as indicated in Figure 8. Any excess of pyroxylin solution will spread over the surface of the glue 31 and can be wiped off.

The whole surface of the solution is covered in this way by alternate strips of glue such as 31, 34 and of paper which has been squeegeed between the strips of glue.

When all is dry the paper is stripped away and the glue is washed off. The strips which have been previously rendered diffractive are now in their turn protected by a layer of glue and the strips which were previously covered with glue have sheets of diffractive gelatine-covered paper such as 27 applied to them with pyroxylin solution squeegeed between as shown at 36, Figure 9. In this way the remaining surface of the cylinder is rendered diffractive. If the strips of glue are made thin and the squeegeeing is carefully done the paper will sink well into the minute angle made at the edges, such as 32, 33, of the strips of glue and the joints between the successive sections of the moulded areas will not be marked by any projecting ribs or like discontinuity of surface, which would be objectionable. The second stage of moulding the strips between those originally moulded on the cylinder 30 is illustrated in Figure 9. When the paper has been stripped off and the glue washed away the cylinder will be ready for use. It will be appreciated that the thicknesses of the films and sheet material generally have been grossly exaggerated in the Figures for the purposes of illustration.

Referring to Figure 10, this shows a supply reel 40 carrying cellulose foil 41, a band of which is led beneath a roller 42 in a water bath 43 and thence around the diffractive-surfaced cylinder 30. The wet foil 41 is pressed against the cylinder 30 by a roller 44 at its on-going side, and a second roller 45 also presses on it at the take-off side, so that the foil is kept firmly in contact with the roller 30 throughout its period of travel between pressing rollers 44, 45. The water acts as a softening agent sufficient to bring the foil to a state soft enough to receive an impression from the moulded surface of the cylinder 30.

The roller 30 is provided with internal heating means to bring it to a temperature somewhat above that of the room so that the wet foil will dry quickly while it is in contact with the roller and the speed of movement is made such that the foil is sufficiently dried by the time it reaches the roller 45 to permit of it retaining the surface-pattern which is impressed upon it by the roller 30. The paper is then fed on to a receiving spool 46 and will be found to bear a brilliant diffractive pattern corresponding to the pattern on the roller.

In an alternative method of producing a diffractive pattern on a cylinder or endless metal band which is intended to be used when diffractive foils are cast upon the cylinder or band in solution form, which is suitable, for example, for the manufacture of cellulose acetate foils, the surface of the cylinder or band is finely finished and covered with glue containing a dichromate. Skins such as the skins 25 are squeegeed thereon over the whole surface while the glue is swollen and when it has dried they are stripped, leaving the cylinder or band covered with diffractive gratings moulded in dichromate glue. This is preferably heated and if the heating is sufficient the glue is converted into a very hard enamel, although such heating is not essential for the casting of cellulose acetate foils. A temperature of, say, 250° C. for about five minutes will, however, convert the glue into a water-insoluble enamel sufficiently hard to act as a material on which foil may be cast, and which is water-resistant so that it could even be used instead of the celluloid in treating "Cellophane" or like materials. The skins 25 may be laid on in such a way as to form a pattern, the lines of the adjacent areas not being necessarily parallel and the areas may be of any desired shape. Thus the boundaries of the juxtaposed areas correspond to the desired design and they form a matrix for the reproduction of the design by the cylinder. The film is then formed by pouring or spreading a film-forming solution upon the roller or band and drying it in contact therewith, after which it is stripped off.

Apart from the preparation of transparent foils it is possible to mould non-transparent material such as coloured celluloid sheet with a diffractive surface. Peculiarly beautiful effects are obtained if black sheets are moulded in this way. A convenient method of moulding patterns on celluloid sheets consists in squeegeeing on to them gelatined paper such as the sheets 27 covered with the pattern 26, using a softening material such as pyroxylin solution between the two surfaces in a similar way to the solution 36 of Figures 8 and 9.

A wide variety of materials may be provided with diffraction rulings according to the invention. Thus, any cellulosic

material or cellulose ester or ether may be employed. The materials may be cast or moulded in a swollen condition according to their respective properties of swelling or not. Further materials which may be used are paper impregnated with alginic acid and aliginates. Substances which are capable of deformation under heat may also be impressed with diffraction rulings such, for example, as certain synthetic resins.

The diffractive foils prepared according to the invention are particularly useful for ornamental and decorative purposes. When using transparent or translucent foils it is possible to enhance the effect by depositing a metallic film, for example, a gold or silver film, upon the surface of the film by cathodic atomisation or other sputtering process.

In British Application No. 8050/37 (Serial No. 468,942), which claims subject-matter divided from the present Application and which bears the same date as the present Application, claims are made to the drying of a swollen gel material in contact with a patterned surface so that the gel material takes up the pattern of the surface and can thereafter act as a matrix for the reproduction of the original surface, and no claim is made herein to the invention claimed in the said patent application.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. A method of reproducing from an original diffraction surface a copy thereof which consists in applying directly to the surface of the original a material capable of taking an impression or cast therefrom, thus forming one or more primary negative replicas, stripping therefrom the primary negative replica or replicas, then making one or more positive replicas of the original grating by applying directly to the said primary negative replica or replicas a second material which does not dissolve or mix with the said negative replica or replicas and is capable of taking an impression or cast therefrom, thereafter separating the second material and primary negative replica from each other and then in like manner making further replicas from the said positive replica or replicas.

2. A method of reproducing from an original diffraction surface a copy thereof of area larger than the original, which consists in taking directly from the original in a material capable of taking an impression or cast therefrom a plurality of casts to form negative replicas, and using these juxtaposed as dies in the formation of a larger positive replica of the diffraction surface in a second material which in the direct casting operation does not dissolve or mix with the first.

3. A method as claimed in Claim 1 or Claim 2 wherein the material employed for making any of the said replicas is a swollen gelatinous material and has the impression produced thereon by being allowed to dry in direct contact with the surface from which the impression is taken.

4. A method as claimed in Claim 3 wherein the gelatinous material is a glue containing a hardening agent and is subjected to treatment for the purpose of hardening it after the surface from which the impression has been taken has been stripped off.

5. A method as claimed in Claim 1 or Claim 2 wherein a replica is made from a cellulosic material and a replica thereof is made from another cellulosic material softened by or dissolved in an agent which has no solvent effect on the first mentioned replica.

6. A method of preparing a plurality of casts of a diffraction surface of a desired area larger than an original diffraction surface which consists in forming from the said original a cast thereof by applying directly thereto a material which is thereafter stripped therefrom, then forming therefrom a plurality of casts by bringing it in contact with a material which is capable of being separated therefrom after casting, then using these casts juxtaposed as dies to form in like manner an enlarged die-surface from which in turn a series of further casts is taken by applying directly a material which in every case is capable of being stripped from the dies after casting if and so far as may be necessary to build up a still further enlarged diffraction surface of the desired area and using the said diffraction surface having the desired area as a matrix for the production of casts in a material which is capable of being stripped from the said matrix.

7. A method as claimed in Claim 6 wherein the material of which the said matrix is composed consists of a glue (for instance a photo-engraving glue) containing a hardening agent and is subjected to heat for the purpose of hardening it.

8. A method as claimed in Claim 2 or Claim 6 wherein the enlarged diffraction surface is employed as a die or matrix to form a diffraction surface upon a thin

continuous film or sheet of a cellulosic or alginic material of the kind described.

9. A method as claimed in Claim 8 wherein the thin film is pre-formed, treated with a softening agent sufficient to bring it to soft state, and dried while in contact with the die or matrix.

10. A method as claimed in Claim 8 wherein the diffraction surface is formed on a roller or endless band and the film is formed by pouring or spreading a film-forming solution (for example, cellulose acetate solution) over the roller or band, drying it in contact therewith and stripping it therefrom.

11. A method of executing a design on a surface which consists in juxtaposing a number of separate diffraction areas reproduced in accordance with any one of the preceding claims so that their boundaries correspond to the design.

12. A method as claimed in Claim 11 in which the juxtaposed areas are used as a matrix or to form a matrix for the duplication of the said design in a material which is capable of being stripped from the said matrix.

13. A copy of a diffraction surface when prepared by the method claimed in any one of the preceding claims.

Dated this 16th day of October, 1936.
BOULT, WADE & TENNANT,
111 & 112, Hatton Garden, London, E.C.1,
Chartered Patent Agents.

Leamington Spa: Printed for His Majesty's Stationery Office, by the Courier Press.—1937.

[This Drawing is a reproduction of the Original on a reduced scale.]

Fig.1.

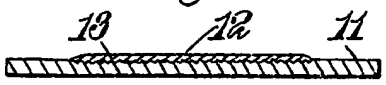
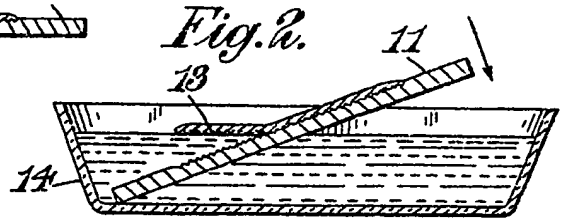


Fig.2.



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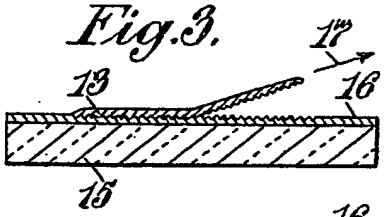

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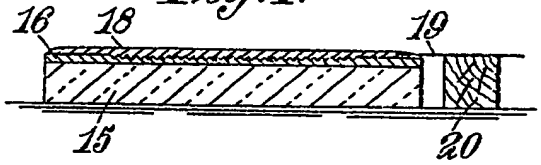

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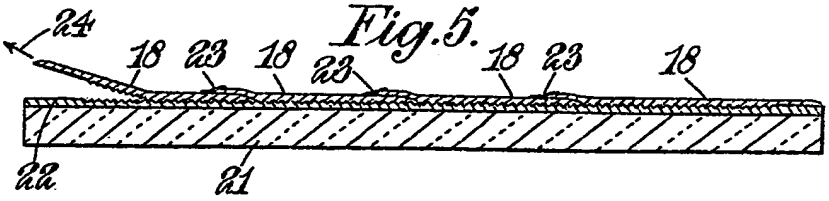
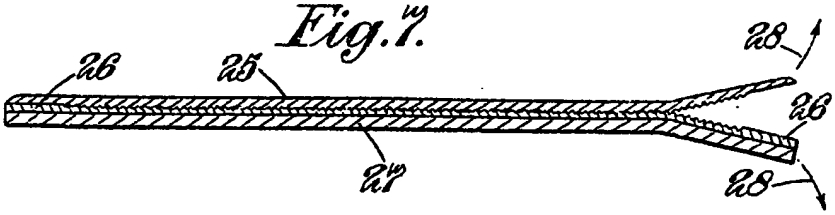


Fig.6.

Fig.7.



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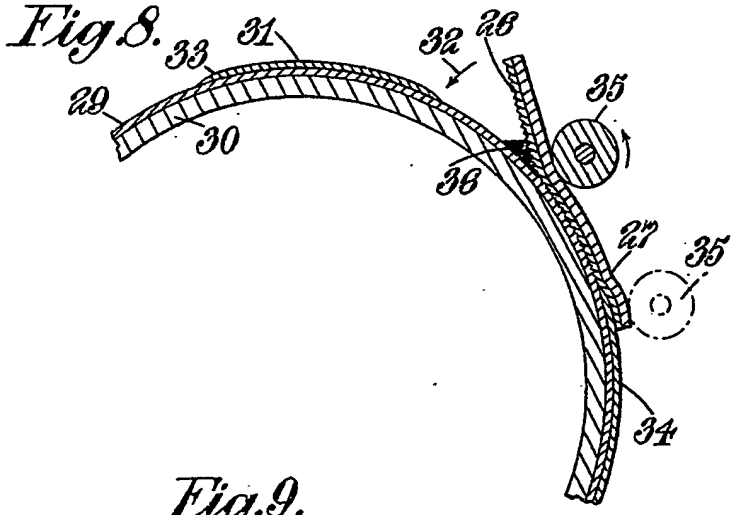

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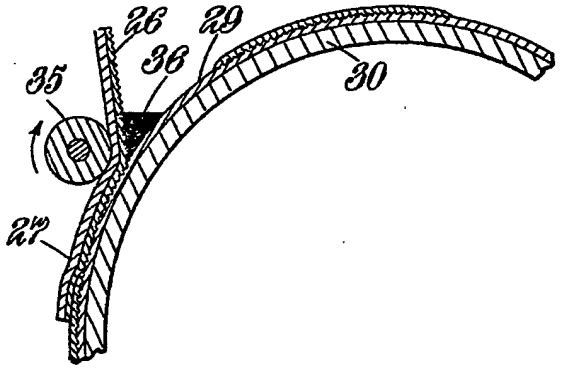

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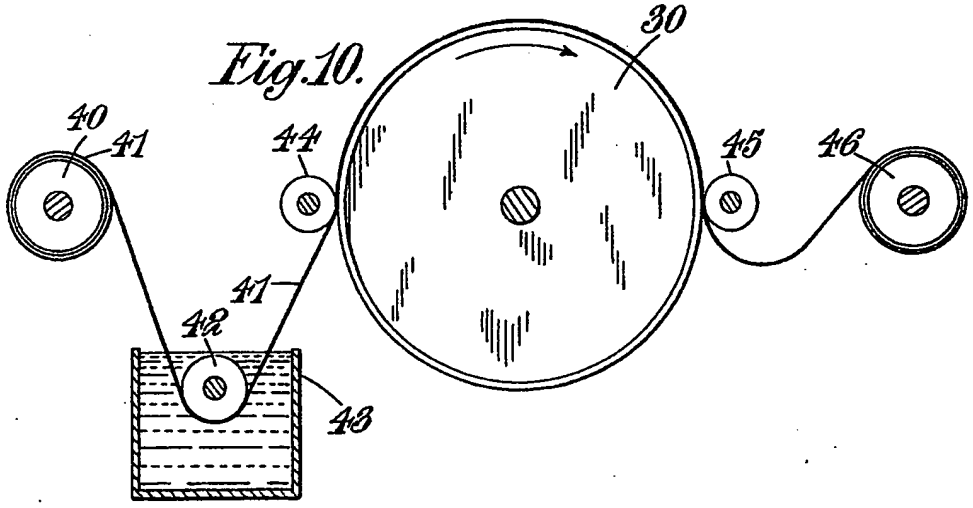


Malby & Sons, Photo-Litho.

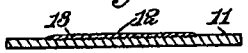
468,893 COMPLETE SPECIFICATION

SHEET 1

2 SHEETS
SHEET 2

[This Drawing is a reproduction of the Original on a reduced scale.]

Fig.1.



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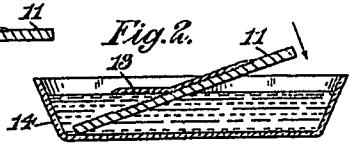

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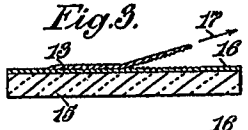

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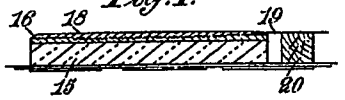
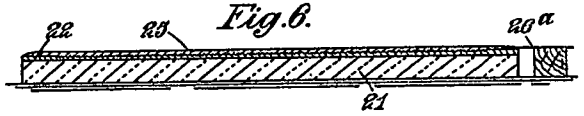


Fig.5.

Fig.6.



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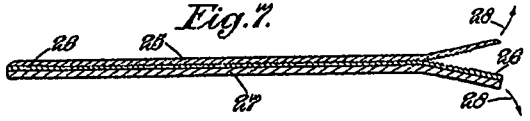

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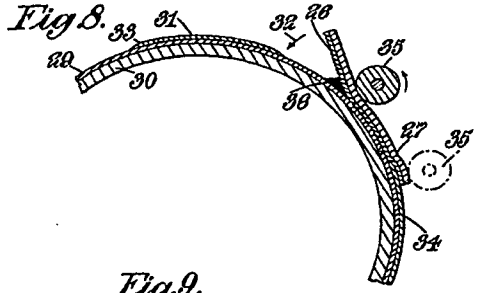

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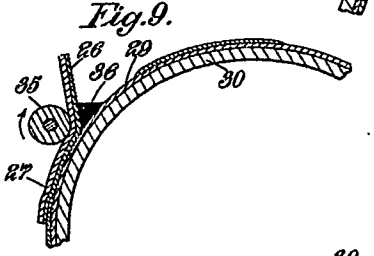

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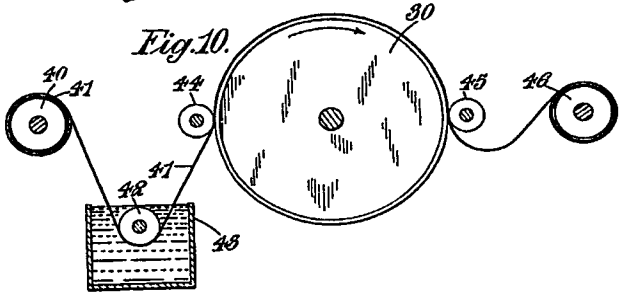

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